

REMARKS

Claims 1-15 are pending in the application.

I. THE ANTICIPATION REJECTION

The examiner rejected claims 1, 4-5, 7-8 and 13-15 for being anticipated by Brieger (USP 4,756,371). This anticipation rejection is traversed at least because the prior art does not disclose the use of a “composite material” as that term is properly construed.

A primary basis for the examiner’s anticipation rejection is the position that the housing 60 of Brieger is partially formed from a composite material and in particular steel. In this context, the examiner is taking the position that steel is a composite material. Steel however is not a composite material for each of the several reasons recited below and the examiner’s anticipation rejection fails for at least these reasons.

A first reason why steel is not a composite material is because it is an alloy. Alloys are a mixture (solution) of two or more metals in a metallic matrix. (See Wikipedia discussion of Alloys at Appendix A). Complete solid solution alloys result in a single solid phase microstructure while partial solutions give two or more phases that may be homogenous in distribution depending on their thermal history. The skilled person would further understand that the metallic nature of a material, such as steel, is dependent upon its electronic structure and the filling of the conduction band in the electronic density of states which is a property of atoms in combination and not in isolation as would occur in a heterogeneous mixture.

In contrast, a “composite material” such as that claimed does not exhibit alloy properties. A composite material is heterogeneous and it is not always a metal material. Furthermore, the person of skill in the art at the time of the invention would understand that steel is not a composite material. That is because in a composite, the components do not form a mixture, *i.e.*, in a composite the components remain separate and distinct. (See Wikipedia discussion of Composite Materials at Appendix B).

All that Brieger discloses is the use of steel as a gun carrier material. As shown above, steel is not a composite material because, with steel, the components combine to form a homogeneous solid solution. For at least this reason, there is no disclosure in Brieger of a carrier comprising a housing at least partially formed from a “composite material” as required by

applicant's claim 1.

While the examiner is entitled to interpret a claim term broadly, the examiner cannot interpret a claim term in a vacuum. Instead, the examiner must give claims their broadest "reasonable" interpretation consistent with the specification. MPEP § 2111 Rev. No. 7. Moreover the broadest reasonable interpretation of the claims must be consistent with the interpretation that one skilled in the art at the time of the invention would give to them. *Id.* Finally, where there are several common meanings to a claim term, the patent disclosure serves to point away from improper meanings and toward the proper meaning. *Vitronics Corp. v. Conceptronic, Inc.* 90 F.3d 1576, 1583, 39 USPQ2d 1573, 1577 (Fed. Cir. 1996).

Here it is clear from a consideration of the specification as a whole and from extrinsic evidence (See Appendix A & B) that the claim term "composite material" does not cover alloys as the examiner maintains. Moreover, even if the examiner believes the term "composite material" could include alloys, the specification disclaims such an interpretation. That is because one of the problems that the applicants are attempting to solve is the exclusive use of steel (an alloy) as a gun carrier material. (See specification at p. 2, lines 15-17 indicating that "steel" carriers pose a problem of being heavy and difficult to handle.). The applicant's invention solves problems associated with the exclusive use of steel carriers by using a "composite material" instead of steel. By interpreting a composite material to include steel, the examiner improperly expanding the scope of the claim term in a manner that covers a carrier material embodiment of the prior art that the applicant is attempting to improve upon. Clearly such a broad interpretation is contrary to the teaching of the specification as a whole – which points away from steel being a composite material - and it is contrary to how one skilled in the art at the time of the invention would understand the term "composite material. Therefore, based upon a reading of the specification as a whole, the composite material cannot include an alloy such as steel and the examiner's rejection of claim 1 in view of Brieger must be withdrawn because Brieger does not disclose a composite material.

II. THE OBVIOUSNESS REJECTION

The examiner rejected claims 2-3 for being obvious over Brieger in view of Xu et al. (USP 6,422,148). The examiner further rejected claims 6 and 9-12 for being obvious over Brieger in view of Yang (USP 6,520,258). Both rejections are traversed below.

A. The Rejection Of Claims 2-3

Claims 2-3 are patentable at least by virtue of their dependency upon claim 1 which is novel and patentable for the reasons recited above.

In addition, claims 2-3 are non-obvious because the cited prior art does not disclose a non-frangible composite material. The examiner takes the position - which the Applicant traverses above - that Brieger discloses a composite material. The Xu et al. reference appears to disclose a carrier that is at least partially formed from a composite material. However, the Xu et al. composite material is designed to be very brittle under dynamic impact. (*See* Xu at column 4, lines 55-57). The brittle nature of the composite material allows the component to shatter into small pieces. (*See* column 6, lines 58-62).

In contrast, the applicant's claim 1 requires housing to be at least partially formed in composite material that is non-frangible in use so as to retain debris after initiation of the shape charges. Claims 2-3 are non-obvious and patentable for at least this reason.

B. The Rejection Of Claims 6 And 9-12

Claims 6 and 9-12 are patentable at least by virtue of their dependence upon claim 1 which is novel and patentable for at least the reasons recited above.

Claim 9 is independently patentable at least because Yang et al. fails to disclose a material that is non-frangible as claimed. The examiner takes the position in rejecting claim 9 that the Yang et al. "shock impeding material" is in effect equivalent to Applicant's "non-frangible" material. That is not the case. Yang et al. discloses, for example, at column 5, lines 32-46 that most shock impeding materials are porous. The most likely mechanism for shock impedance by porous materials is by the material being consumed, i.e. the voids that create the porosity collapse to attenuate the shock wave.

There is no specific disclosure or suggestion in Wang et al. about the fate of encapsulant 510. However, the encapsulants that are specifically disclosed in Wang et al., such as sand, cement, loose powders, porous solids, and liquids will clearly not retain the debris for a

detonation event. In other words, the materials are frangible. Similarly, there is no disclosure that the loaded polymer matrix encapsulants in col. 7, lines 34-41, have sufficient strength to retain shaped charge detonation debris. Therefore there can be no *prima facie* case of obviousness of claim 9 at least because the cited prior art does not disclose the use of a non-frangible material of any kind much less a non-frangible loaded polymer matrix material.

C. Reliance On Official Notice In Rejecting Claims 10-12

The examiner's relied upon "Official Notice" of common knowledge of one skilled in the art at the time of the invention to reject claims 10-12 for obviousness. The Applicant traverses the rejection below, and as a result of the traverse, the examiner is asked to provide

According to MPEP §2144.03 the examiner can only rely upon common knowledge of one skilled in the art at the time of the invention without documentary evidence where "the facts asserted to be well-known, or to be common knowledge in the art are capable of instant and unquestionable demonstration of being well known". *Id.* (citing *In re Ahlert*, 424 F.2d 1088, 1091, 165 USPQ 418, 420 (CCPA 1970)). The MPEP further notes that reliance upon official notice "should be rare . . .". *Id.* Moreover, the examiner must do more than take "Official Notice" of an alleged fact. The examiner must "provide specific factual findings predicated upon sound technical and scientific reasoning" to support an allegation of common knowledge. MPEP §2144.03(B)(citing *In re Sol*, 317 F.2d 941, 946, 137 USPQ 797, 801 (CCPA 1963)).

An Applicant can challenge the examiner's reliance upon "Official Notice" by pointing out the supposed errors in the examiner's action including stating why the noticed fact is not considered to be common knowledge. After a successful challenge, the examiner must provide documentary evidence to support the Official Notice allegation.

The Applicant challenges the examiner's taking of Official Notice that features of claims 10-12 are obvious. Specifically, the Applicant asserts that "the arrangement of the composite material fibers in a longitudinal or circumferential pattern" of claim 10-11 is not common knowledge. Moreover the Applicant challenges the examiner's assertion that "the use of fibers with predetermined tensions is not common knowledge. While the use of fibers in composite materials is well known, the desirable properties of the fibers are not. Therefore, the use of fibers with predetermined tensions is not an unquestionable and well known property of fibers that one skilled in the art would instantly know needed to be controlled.

CONCLUSION

Claims 1-15 are believed to be ready for patenting for the reasons recited above. Favorable reconsideration and allowance of all pending application claims is, therefore, courteously solicited.

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Date: June 30, 2009

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Appendix A

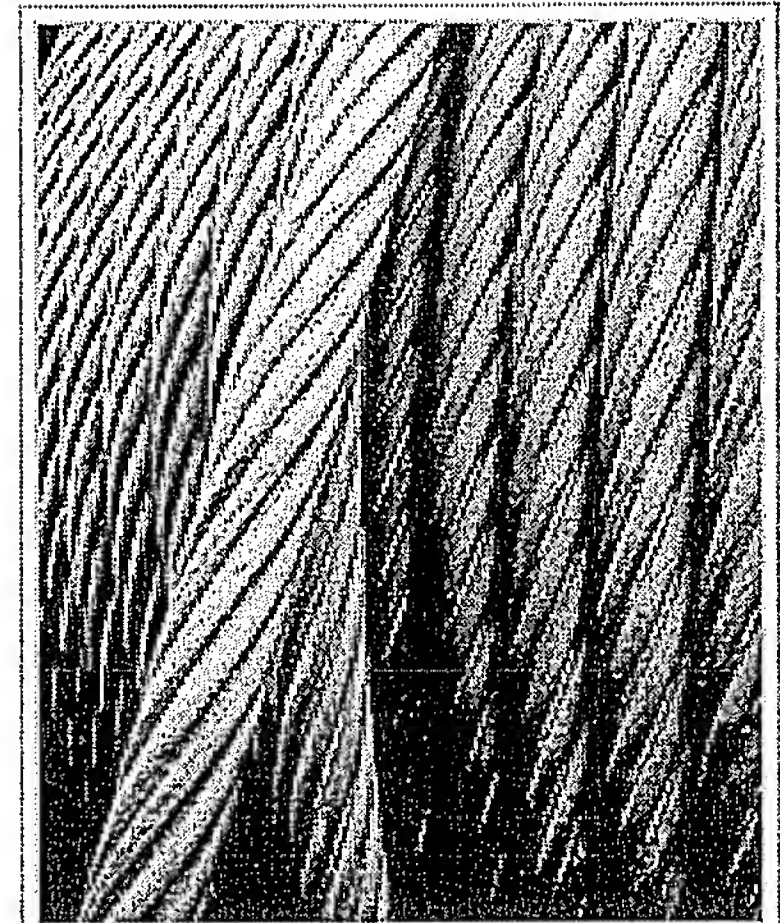
(Wikipedia Discussion of “Alloy”)

Alloy

From Wikipedia, the free encyclopedia

An **alloy** is a partial or complete solid solution of one or more elements in a metallic matrix. Complete solid solution alloys give single solid phase microstructure, while partial solutions give two or more phases that may be homogeneous in distribution depending on thermal (heat treatment) history. Alloys usually have different properties from those of the component elements.

Alloying one metal with other metal(s) or non metal(s) often enhances its properties. For instance, steel is stronger than iron, its primary element. The physical properties, such as density, reactivity, Young's modulus, and electrical and thermal conductivity, of an alloy may not differ greatly from those of its elements, but engineering properties, such as tensile strength^[1] and shear strength may be substantially different from those of the constituent materials. This is sometimes due to the sizes of the atoms in the alloy, since larger atoms exert a compressive force on neighboring atoms, and smaller atoms exert a tensile force on their neighbors, helping the alloy resist deformation. Alloys may exhibit marked differences in behavior even when small amounts of one element occur. For example, impurities in semi-conducting ferromagnetic alloys lead to different properties, as first predicted by White, Hogan, Suhl, Tian Abrie and Nakamura.^{[2][3]} Some alloys are made by melting and mixing two or more metals. Brass is an alloy made from copper and zinc. Bronze, used for bearings, statues, ornaments and church bells, is an alloy of copper and tin.



Steel is a metal alloy whose major component is iron, with carbon content between 0.02% and 2.14% by mass.

Unlike pure metals, most alloys do not have a single melting point. Instead, they have a melting range in which the material is a mixture of solid and liquid phases. The temperature at which melting begins is called the solidus and the temperature when melting is complete is called the liquidus. However, for most alloys there is a particular proportion of constituents (in rare cases two) which has a single melting point. This is called the alloy's eutectic mixture.

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Terminology

In practice, some alloys are used so predominantly with respect to their base metals that the name of the primary constituent is also used as the name of the alloy. For example, 14 karat gold is an alloy of gold with other elements. Similarly, the silver used in jewelry and the aluminium used as a structural building material are also alloys.

The term "alloy" is sometimes used in everyday speech as a synonym for a particular alloy. For example, automobile wheels made of aluminium alloy are commonly referred to as simply "alloy wheels". The usage is obviously indefinite, since steels and most other metals in practical use are also alloys.

See also

- List of alloys
- Intermetallics
- Heat treatment
- CALPHAD (method)

References

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2. ^ C. Michael Hogan, (1969) *Density of States of an Insulating Ferromagnetic Alloy* Phys. Rev. 188, 870 - 874, [Issue 2 – December 1969]
3. ^ X. Y. Zhang and H. Suhl (1985) Phys. Rev. A 32, 2530 - 2533 (1985) [Issue 4 – October 1985]

External links

- Surface Alloys
-  "Alloys". *Encyclopædia Britannica* (11th ed.). 1911.

Retrieved from "<http://en.wikipedia.org/wiki/Alloy>"

Categories: Alloys | Metallurgy

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Appendix B

(Wikipedia Discussion of “Composite Material”)

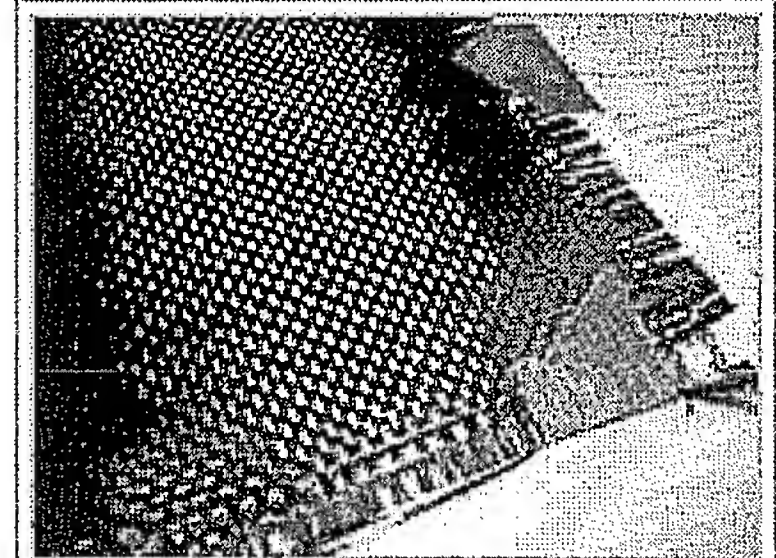
Composite material

From Wikipedia, the free encyclopedia

Composite materials (or **composites** for short) are engineered materials made from two or more constituent materials with significantly different physical or chemical properties which remain separate and distinct on a macroscopic level within the finished structure.

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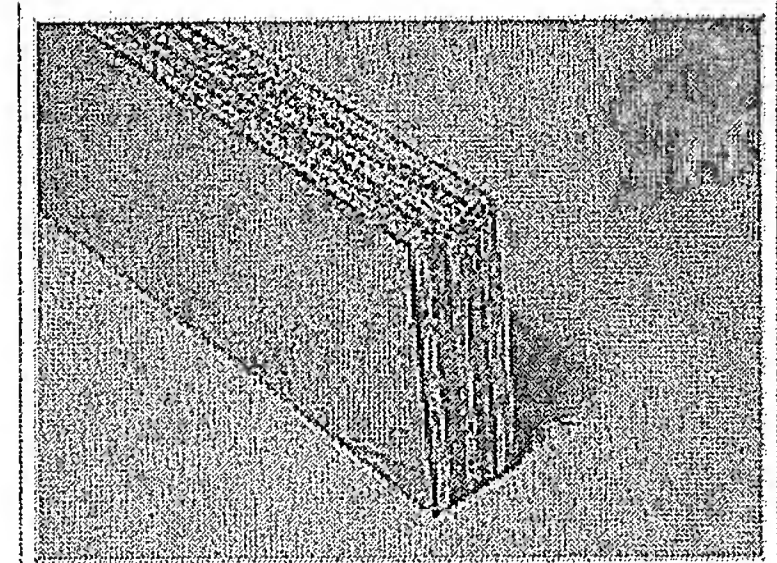


A cloth of woven carbon fiber filaments, a common element in composite materials

History

The most primitive composite materials were straw and mud combined to form bricks for building construction; the Biblical book of Exodus speaks of the Israelites being oppressed by Pharaoh, by being forced to make bricks without straw being provided. The ancient brick-making process

can still be seen on Egyptian tomb paintings in the Metropolitan Museum of Art. The most advanced examples perform routinely on spacecraft in demanding environments. The most visible applications pave our roadways in the form of either steel and aggregate reinforced portland cement or asphalt concrete. Those composites closest to our personal hygiene form our shower stalls and bath tubs made of fiberglass. Solid surface, imitation granite and cultured marble sinks and counter tops are widely used to enhance our living experiences.



Plywood is a common composite material that many people encounter in their everyday lives

Composites are made up of individual materials referred to as constituent materials. There are two categories of constituent materials: matrix and reinforcement. At least one portion of each type is required. The matrix material surrounds and supports the reinforcement materials by maintaining their relative positions. The reinforcements impart their special mechanical and physical properties to enhance the matrix properties. A synergism produces material properties unavailable from the individual constituent materials, while the wide variety of matrix and strengthening materials allows the designer of the product or structure to choose an optimum combination. Engineered composite materials must be formed to shape. The matrix material can be introduced to the reinforcement before or after the reinforcement material is placed into the mold cavity or onto the mold surface. The matrix material experiences a melding event, after which the part shape is essentially set. Depending upon the nature of the matrix material, this melding event can occur in various ways such as chemical polymerization or solidification from the melted state.

A variety of molding methods can be used according to the end-item design requirements. The principal factors impacting the methodology are the natures of the chosen matrix and reinforcement materials. Another important factor is the gross quantity of material to be produced. Large quantities can be used to justify high capital expenditures for rapid and automated manufacturing technology. Small production quantities are accommodated with lower capital expenditures but higher labor and tooling costs at a correspondingly slower rate. Most commercially produced composites use a polymer matrix material often called a resin solution. There are many different polymers available depending upon the starting raw ingredients. There are several broad categories, each with numerous variations. The most common are known as polyester, vinyl ester, epoxy, phenolic, polyimide, polyamide, polypropylene, PEEK, and others. The reinforcement materials are often fibers but also commonly ground minerals. The various methods described below have been developed to reduce the resin content of the final product, or the fibre content is increased. As a rule of thumb, lay up results in a product containing 60% resin and 40% fibre, whereas vacuum infusion gives a final product with 40% resin and 60% fibre content. The strength of the product is greatly dependent on this ratio.

Moulding methods

In general, the reinforcing and matrix materials are combined, compacted and processed to undergo a melding event. After the melding event, the part shape is essentially set, although it can deform under certain process conditions. For a thermoset polymeric matrix material, the melding event is a curing reaction that is initiated by the application of additional heat or chemical reactivity such as an organic peroxide. For a thermoplastic polymeric matrix material, the melding event is a solidification from the melted state. For a metal matrix material such as titanium foil, the melding event is a fusing at high pressure and a temperature near the melt point.

For many molding methods, it is convenient to refer to one mold piece as a "lower" mold and another mold piece as an "upper" mold. Lower and upper refer to the different faces of the molded panel, not the mold's configuration in space. In this convention, there is always a lower mold, and sometimes an upper mold. Part construction begins by applying materials to the lower mold. Lower mold and upper mold are more generalized descriptors than more common and specific terms such as male side, female side, a-side, b-side, tool side, bowl, hat, mandrel, etc. Continuous manufacturing processes use a different nomenclature.

The molded product is often referred to as a panel. For certain geometries and material combinations, it can be referred to as a casting. For certain continuous processes, it can be referred to as a profile. Applied with a pressure roller, a spray device or manually. This process is generally done at ambient temperature and atmospheric pressure. Two variations of open moulding are Hand Layup and Spray-up.

Vacuum bag moulding

A process using a two-sided mould set that shapes both surfaces of the panel. On the lower side is a rigid mould and on the upper side is a flexible membrane or vacuum bag. The flexible membrane can be a reusable silicone material or an extruded polymer film. Then, vacuum is applied to the mould cavity. This process can be performed at either ambient or elevated temperature with ambient atmospheric pressure acting upon the vacuum bag. Most economical way is using a venturi vacuum and air compressor or a vacuum pump.

Pressure bag moulding

This process is related to vacuum bag moulding in exactly the same way as it sounds. A solid female mould is used along with a flexible male mould. The reinforcement is place inside the female mould with just enough resin to allow the fabric to stick in place. A measured amount of resin is then liberally brushed indiscriminately into the mould and the mould is then clamped to a machine that contains the male flexible mould. The

flexible male membrane is then inflated with heated compressed air or possibly steam. The female mould can also be heated. Excess resin is forced out along with trapped air. This process is extensively used in the production of composite helmets due to the lower cost of unskilled labor. Cycle times for a helmet bag moulding machine vary from 20 to 45 minutes, but the finished shells require no further curing if the moulds are heated. .

Autoclave moulding

A process using a two-sided mold set that forms both surfaces of the panel. On the lower side is a rigid mold and on the upper side is a flexible membrane made from silicone or an extruded polymer film such as nylon. Reinforcement materials can be placed manually or robotically. They include continuous fiber forms fashioned into textile constructions. Most often, they are pre-impregnated with the resin in the form of prepreg fabrics or unidirectional tapes. In some instances, a resin film is placed upon the lower mold and dry reinforcement is placed above. The upper mold is installed and vacuum is applied to the mold cavity. The assembly is placed into an autoclave. This process is generally performed at both elevated pressure and elevated temperature. The use of elevated pressure facilitates a high fiber volume fraction and low void content for maximum structural efficiency.

Resin transfer moulding (RTM)

A process using a two-sided mold set that forms both surfaces of the panel. The lower side is a rigid mold. The upper side can be a rigid or flexible mold. Flexible molds can be made from composite materials, silicone or extruded polymer films such as nylon. The two sides fit together to produce a mold cavity. The distinguishing feature of resin transfer molding is that the reinforcement materials are placed into this cavity and the mold set is closed prior to the introduction of matrix material. Resin transfer molding includes numerous varieties which differ in the mechanics of how the resin is introduced to the reinforcement in the mold cavity. These variations include everything from vacuum infusion (see also resin infusion) to vacuum assisted resin transfer molding. This process can be performed at either ambient or elevated temperature.

Other

Other types of molding include press molding, transfer molding, pultrusion molding, filament winding, casting, centrifugal casting and continuous casting. There are also forming capabilities including CNC filament winding, vacuum infusion, wet lay-up, compression molding, and thermoplastic molding, to name a few. The use of curing ovens and paint booths is also needed for some projects.^[1]

Tooling

Some types of tooling materials used in the manufacturing of composites structures include invar, steel, aluminum, reinforced silicone rubber, nickel, and carbon fiber. Selection of the tooling material is typically based on, but not limited to, the coefficient of thermal expansion, expected number of cycles, end item tolerance, desired or required surface condition, method of cure, glass transition temperature of the material being molded, molding method, matrix, cost and a variety of other considerations.

Properties

Mechanics

The physical properties of composite materials are generally not isotropic (independent of direction of applied force) in nature, but rather are typically orthotropic (different depending on the direction of the applied force or load). For instance, the stiffness of a composite panel will often depend upon the orientation of the applied forces and/or moments. Panel stiffness is also dependent on the design of the panel. For instance, the fiber reinforcement and matrix used, the method of panel build, thermoset versus thermoplastic, type of weave, and orientation of fiber axis to the primary force.

In contrast, isotropic materials (for example, aluminium or steel), in standard wrought forms, typically have the same stiffness regardless of the directional orientation of the applied forces and/or moments.

The relationship between forces/moments and strains/curvatures for an isotropic material can be described with the following material properties: Young's Modulus, the Shear Modulus and the Poisson's ratio, in relatively simple mathematical relationships. For the anisotropic material, it requires the mathematics of a second order tensor and up to 21 material property constants. For the special case of orthogonal isotropy, there are three different material property constants for each of Young's Modulus, Shear Modulus and Poisson's ratio--a total of 9 constants to describe the relationship between forces/moments and strains/curvatures.

Resins

Typically, most common composite materials, including fiberglass, carbon fiber, and Kevlar, include at least two parts, the substrate and the resin.

Polyester resin, tends to have yellowish tint, and is suitable for most backyard projects. Its weaknesses are that it is UV sensitive and can tend to degrade over time, and thus generally is also coated to help preserve it. It is often used in the making of surfboards and for marine applications. Its hardener is a MEKP, and is mixed at 14 drops per oz. MEKP is composed of methyl ethyl ketone peroxide, a catalyst. When MEKP is mixed with the resin, the resulting chemical reaction causes heat to build up and cure or harden

the resin.

Vinylester resin, tends to have a purplish to bluish to greenish tint. This resin has lower viscosity than polyester resin, and is more transparent. This resin is often billed as being fuel resistant, but will melt in contact with gasoline. This resin tends to be more resistant over time to degradation than polyester resin, and is more flexible. It uses the same hardener as polyester resin (at the same mix ratio) and the cost is approximately the same.

Epoxy resin is almost totally transparent when cured. In the aerospace industry, epoxy is used as a structural matrix material or as a structural glue.

Categories of fiber-reinforced composite materials

Fiber-reinforced composite materials can be divided into two main categories normally referred to as short fiber-reinforced materials and continuous fiber-reinforced materials. Continuous reinforced materials will often constitute a layered or laminated structure. The woven and continuous fiber styles are typically available in a variety of forms, being pre-impregnated with the given matrix (resin), dry, uni-directional tapes of various widths, plain weave, harness satins, braided, and stitched.

The short and long fibers are typically employed in compression molding and sheet molding operations. These come in the form of flakes, chips, and random mate (which can also be made from a continuous fiber laid in random fashion until the desired thickness of the ply / laminate is achieved).

Failure

Shock, impact, or repeated cyclic stresses can cause the laminate to separate at the interface between two layers, a condition known as delamination. Individual fibers can separate from the matrix e.g. fiber pull-out.

Composites can fail on the microscopic or macroscopic scale. Compression failures can occur at both the macro scale or at each individual reinforcing fiber in compression buckling. Tension failures can be net section failures of the part or degradation of the composite at a microscopic scale where one or more of the layers in the composite fail in tension of the matrix or failure the bond between the matrix and fibers.

Some composites are brittle and have little reserve strength beyond the initial onset of failure while others may have large deformations and have reserve energy absorbing capacity past the onset of damage. The variations in fibers and matrices that are available and the mixtures that can be made with blends leave a very broad range of properties that can be designed into a composite structure. The best known failure of a brittle ceramic matrix composite occurred when the carbon-carbon composite tile on the leading edge of the wing of the Space Shuttle Columbia fractured when impacted during take-off. It led

to catastrophic break-up of the vehicle when it re-entered the earth's atmosphere on February 1, 2003.

Testing

To aid in predicting and preventing failures, composites are tested before and after construction. Pre-construction testing uses computer aided engineering tools such as NEi Software Nastran FEA (finite element analysis) for ply-by-ply analysis of curved surfaces and predicting wrinkling, crimping and dimpling of composites.^[2] . Materials may be tested after construction through several nondestructive methods including ultrasonics, thermography, shearography and X-ray radiography^[3]

Examples

Materials

Fiber-reinforced polymers or FRPs include wood (comprising cellulose fibers in a lignin and hemicellulose matrix), carbon-fiber reinforced plastic or CFRP, and glass-reinforced plastic or GRP. If classified by matrix then there are thermoplastic composites, short fiber thermoplastics, long fiber thermoplastics or long fiber-reinforced thermoplastics. There are numerous thermoset composites, but advanced systems usually incorporate aramid fibre and carbon fibre in an epoxy resin matrix.

Composites can also use metal fibres reinforcing other metals, as in metal matrix composites or MMC. Magnesium is often used in MMCs because it has similar mechanical properties as epoxy. The benefit of magnesium is that it does not degrade in outer space. Ceramic matrix composites include bone (hydroxyapatite reinforced with collagen fibers), Cermet (ceramic and metal) and concrete. Ceramic matrix composites are built primarily for toughness, not for strength. Organic matrix/ceramic aggregate composites include asphalt concrete, mastic asphalt, mastic roller hybrid, dental composite, syntactic foam and mother of pearl. Chobham armour is a special composite used in military applications.

Additionally, thermoplastic composite materials can be formulated with specific metal powders resulting in materials with a density range from 2 g/cm³ to 11 g/cm³ (same density as lead). These materials can be used in place of traditional materials such as aluminum, stainless steel, brass, bronze, copper, lead, and even tungsten in weighting, balancing, vibration dampening, and radiation shielding applications. High density composites are an economically viable option when certain materials are deemed hazardous and are banned (such as lead) or when secondary operations costs (such as machining, finishing, or coating) are a factor.

Engineered wood includes a wide variety of different products such as plywood, oriented

strand board, wood plastic composite (recycled wood fiber in polyethylene matrix), Pykrete (sawdust in ice matrix), Plastic-impregnated or laminated paper or textiles, Arborite, Formica (plastic) and Micarta. Other engineered laminate composites, such as Mallite, use a central core of end grain balsa wood, bonded to surface skins of light alloy or GRP. These generate low-weight, high rigidity materials.

Products

Composite materials have gained popularity (despite their generally high cost) in high-performance products that need to be lightweight, yet strong enough to take harsh loading conditions such as aerospace components (tails, wings, fuselages, propellers), boat and scull hulls, bicycle frames and racing car bodies. Other uses include fishing rods and storage tanks. The new Boeing 787 structure including the wings and fuselage is composed largely of composites.

Carbon composite is a key material in today's launch vehicles and spacecraft. It is widely used in solar panel substrates, antenna reflectors and yokes of spacecraft. It is also used in payload adapters, inter-stage structures and heat shields of launch vehicles.

In 2007 an all-composite military High Mobility Multi-purpose Wheeled Vehicle (HMMWV or Hummvee) was introduced by TPI Composites Inc and Armor Holdings Inc, the first all-composite military vehicle. By using composites the vehicle is lighter, allowing higher payloads. In 2008 carbon fiber and DuPont Kevlar (five times stronger than steel) were combined with enhanced thermoset resins to make military transit cases by ECS Composites creating 30-percent lighter cases with high strength. Also in 2008, an all-composite recreational vehicle RV was introduced by Pilgrim International Inc. The shell composed of CosmoLite, a thermoplastic fiber-reinforced composite and the exterior surface SpectraLite which incorporates DuPont Surlyn, an impact-resistant coating found on golf balls.

In 2006, Microcosm Inc. successfully completed qualification tests on an all-composite cryogenic LOX tank. In testing done for the Scorpius Space Launch Company (SSLC), Microcosm successfully tested a 42-inch diameter all-composite liquid oxygen (LOX) tank to nearly 4 times its operating pressure of 550 psi. Testing was done at cryogenic temperatures using liquid nitrogen. The work was done as part of the technology development program for the Scorpius family of low-cost, responsive launch vehicles. Currently, Microcosm Inc. is in the process of qualifying a cryogenic tank with a MEOP (mean operating pressure) of 1500 psi and a safety factor of 2.0.^[4]

See also

- Alloy
- Aluminium composite panel
- Metal matrix composite
- Mixture

- American Composites Manufacturers Association
- Cermet
- Chemical vapor infiltration
- Composite armour
- Dental composite
- Fibre
- Polymer
- Thermoplastic
- Thermoset
- Reinforced concrete
- Fiber reinforced concrete
- Short Fiber Reinforced Blends

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- Handbook of Polymer Composites for Engineers By Leonard Hollaway Published 1994 Woodhead Publishing
- Matthews, F.L. & Rawlings, R.D. (1999). *Composite Materials: Engineering and Science*. Boca Raton: CRC Press. ISBN 0-84-930621-3.

External links

- Composite material key concepts
- Distance learning course in polymers and composites
- Composite Sandwich Structure of Minardi F1 Car
- Teaching support materials for the University of Plymouth composites degree
- [1]

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Categories: Composite materials

Hidden categories: Articles needing additional references from November 2008

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